A Compilation of Spatial Digital Databases for Selected U.S. Geological Survey Nonfuel Mineral Resource Assessments for Parts of Idaho and Montana

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Open-File Report 2007-1101

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U.S. Geological Survey

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Suggested citation:
Carlson, Mary H., Zientek, Michael L., Causey, J. Douglas, Kayser, Helen Z., Spanski, Gregory T., Wilson, Anna B., Van Gosen, Bradley S., and Trautwein, Charles M., 2007, A compilation of spatial digital databases for selected U.S. Geological Survey nonfuel mineral resource assessments for parts of Idaho and Montana: U.S. Geological Survey Open-File Report 2007-1101 [http://pubs.usgs.gov/of/2007/1101/].

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Abstract

This report compiles selected results from 13 U.S. Geological Survey (USGS) mineral resource assessment studies conducted in Idaho and Montana into consistent spatial databases that can be used in a geographic information system. The 183 spatial databases represent areas of mineral potential delineated in these studies and include attributes on mineral deposit type, level of mineral potential, certainty, and a reference. The assessments were conducted for five 1° x 2° quadrangles (Butte, Challis, Choteau, Dillon, and Wallace), several U.S. Forest Service (USFS) National Forests (including Challis, Custer, Gallatin, Helena, and Payette), and one Bureau of Land Management (BLM) Resource Area (Dillon). The data contained in the spatial databases are based on published information: no new interpretations are made. This digital compilation is part of an ongoing effort to provide mineral resource information formatted for use in spatial analysis. In particular, this is one of several reports prepared to address USFS needs for science information as forest management plans are revised in the Northern Rocky Mountains.

Introduction

Legislation to establish the U.S. Geological Survey for "classification of the public lands, and examination of the geological structure, mineral resources, and products of the national domain" was included in the bill appropriating funds for the Federal Government for the fiscal year beginning July 1, 1879. Since that time, the USGS has studied and provided impartial information on the occurrence, quality, quantity, and availability of mineral resources (Kropschot, 2006). Mineral resource assessments are one way in which this information is communicated.

This report compiles the results of two USGS programs that assessed undiscovered mineral resource potential in Idaho and Montana. The first program assessed the mineral potential of 1° x 2° quadrangles whereas the second focused specifically on National Forests. Because USGS assessment methodology evolves, in order to meet the changing needs of the end-users and to address the quality and quantity of available information, the assessment methods for the two programs are different. However, both approaches delineate areas with potential for undiscovered mineral resources associated with a particular deposit type and estimate the degree of potential for the area.

This report compiles areas of mineral potential and their degree of potential from published mineral resource maps into consistent spatial databases. The 13 USGS mineral resource assessment areas included in this compilation are (1) the Absaroka-Beartooth study area, Custer and Gallatin National Forests (Hammarstrom and others, 1993); (2) the Dillon BLM Resource Area (Hammarstrom and others, 1999; Van Gosen and others, 1998a; Van Gosen and others, 1998b); (3) the Gallatin National Forest (Wilson and others, 2005); (4) the Helena National Forest (Tysdal and others, 1996; Green and Tysdal, 1996); (5) the National Forest roadless areas in Idaho (Johnson and Worl, 1991); (6) the Payette National Forest (Bookstrom and others, 1998); (7) the Custer National Forest in the Pryor Mountains (Van Gosen and others, 1996); (8) the Butte 1° x 2° quadrangle (Elliott and others, 1992a; Elliott and others, 1992b; Elliott and others, 1993b); (9) the Challis 1° x 2° quadrangle (Fisher and Johnson, 1995); (10) the Challis National Forest (Worl and others, 1989); (11) the Choteau 1° x 2° quadrangle (Earhart and others, 1981b); (12) the Dillon 1° x 2° quadrangle (Pearson and others, 1990; Pearson and others, 1991; Pearson and others, 1992a; Pearson and others, 1992b); and (13) the Wallace 1° x 2° quadrangle (Harrison, Cressman, and others, 1986; Harrison, Domenico, and Leach, 1986a; Harrison, Domenico, and Leach, 1986b; Harrison and others, 1986a; Harrison and others, 1986b).

The mineral resource maps developed for these assessments were published in a variety of formats: most commonly as printed material, but also as spatial database files using the ESRI coverage and shapefile format, as well as the USGS GSMAP format (Selner and Taylor, 1993). This report describes the mineral resource assessments, the methods used to convert the mineral resource map data into a digital format, and the spatial database file structures and relationships. This report does not provide all digital data needed to reproduce the printed image of the resource assessment map; base material, geologic features selected from geologic maps used to provide context, or point data derived from USGS mineral occurrence databases are not included in this compilation. Spatial data commonly used as base material in printed maps may be obtained from a variety of commercial and government sources. Larsen and others (2004) and Zientek and others (2005) published digital geologic maps that cover these study areas. Mineral occurrence data from the USGS Mineral Resources Data System (MRDS) can be obtained online from *http://tin.er.usgs.gov/mrds/* [Accessed November 8, 2006].

This digital compilation is part of an ongoing effort to provide mineral resource information as databases for use in spatial analysis. In particular, this is one of several reports prepared to address USFS needs for science information as forest management plans are revised in the Northern Rocky Mountains (Zientek and Kropschot, 2005). The results of mineral resource assessments will be used in conjunction with mineral deposit (Spanski, 2001; Klein, 2004, Spanski, 2004) and mining claim information (Causey, 2005) to indicate where minerals-related activities might take place in the near future.

Acknowledgements

Jeremy C. Larsen and Kenneth C. Assmus reviewed attribute information of the spatial datasets for completeness. Illustrations in this report were prepared by Kenneth C. Assmus. Pamela D. Derkey reviewed and prepared the metadata for this report. Technical reviews by Karen Bolm and Barry Moring improved the manuscript.

Assessment Methodologies

The mineral resource potential of an area is a measure of likelihood of occurrence of undiscovered minerals resources in a defined area that may become valuable within the foreseeable future (Taylor and Steven, 1983; Goudarzi, 1984). The results presented in this report derive from two different methodologies used by the USGS to assess mineral potential (Shawe, 1981; Singer, 1993). Both approaches are based on deposit models and show areas where undiscovered resources may occur. However, they differ significantly in how they represent the potential of these areas. One method provides qualitative ranks (such as high, medium, and low) to indicate favorability (Shawe, 1981). The other method quantitatively estimates the amount of undiscovered metal that may be present (Singer, 1993).

Under the Conterminous United States Mineral Appraisal Program (CUSMAP) in the 1970s and 1980s, the USGS assessed the mineral resource potential of selected 1° x 2° quadrangles to assist in formulating a sound, long-range national minerals policy and to assist Federal, State, and local governments in making decisions that involve land-use planning. Selected assessment results of the Butte, Choteau, Challis, Dillon, and Wallace CUSMAP studies are included in this compilation (fig. 1, table 1).

Although the methodology differed for each of the CUSMAP mineral resource assessments, this general procedure was followed:

1. Geologic, geochemical, geophysical, and other data pertinent to the occurrence of mineral deposits were collected and compiled.
2. The types of mineral deposits that exist and could exist in the study area were determined.
3. For each deposit type, descriptive models and recognition criteria were developed or applied. Recognition criteria are geologic parameters that affect the favorability for the presence of a mineral deposit.
4. The areal distribution and relative importance of recognition criteria were evaluated. This resulted in the delineation of areas where undiscovered deposits could occur.
5. The mineral potential was assessed based on the presence and relative importance of recognition criteria. In this step, the areas delineated in step 4 were ranked according to their favorability for the occurrence of undiscovered mineral deposits.

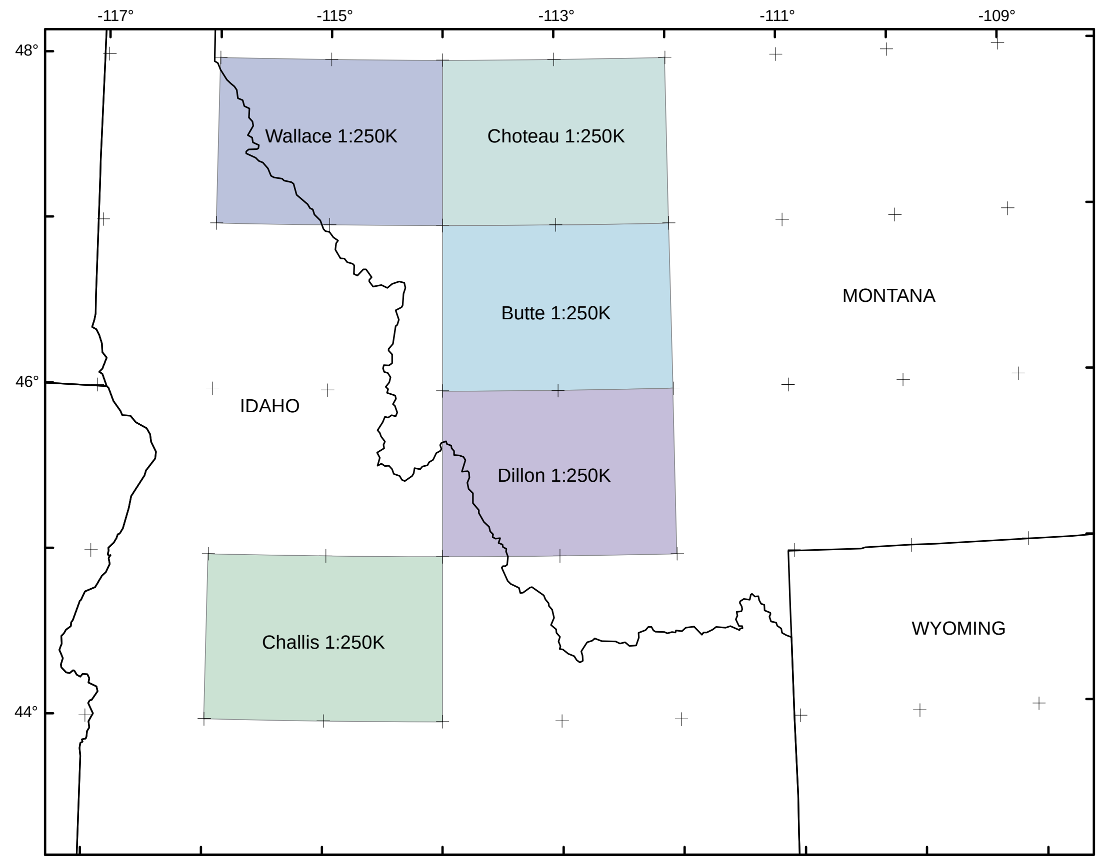

Figure 1. Sketch map of the study area, showing the locations of five study areas assessed by the USGS Conterminous Mineral Resource Assessment Program in Idaho and Montana.

Table 1. Summary of mineral resource studies that did not use the 3-part form of mineral resource assessment.

Mineral resource assessment study	Assessment procedure	Mineral potential terms listed in decreasing order of favorability	Certainty or confidence of the study area as defined in original publication	Reference for assessment	Reference for mineral potential definitions
Choteau 1° x 2° quadrangle, Montana	Areas of mineral potential inferred to be favorable for surface or near-surface ore deposits are based on geology and geochemistry. Only one area with potential for concealed porphyry deposits was outlined using geophysics.	favorable not ranked	geophysical extension coded in ArcInfo dataset *chotcumog*	Earhardt and others (1981a)	
Wallace 1° x 2° quadrangle, Montana and Idaho	From occurrence models, criteria were developed that allowed diagnostic data to be numerically scored. Subareas of the quadrangle were identified, outlined, and assigned numerical favorability scores. The number of different kinds of diagnostic data and the sum of favorability scores were entered into a matrix diagram that was subdivided into 7 levels of probability of ore deposit occurrence.	highly diagnostic moderately diagnostic slightly diagnostic highly suggestive moderately suggestive slightly diagnostic no diagnostic data unfavorable		Harrison and others (1986c)	
Dillon 1° x 2° quadrangle, Idaho and Montana	Descriptive models were developed for each deposit type and important characteristics (favorability criteria) relevant to the formation or localization of the deposit were identified. If the important characteristics are both few and simple or are not available at the scale of the study, the assessment was made qualitatively. If enough information was available, the resource potential was assessed using GIS procedures. For manipulation in a GIS, each criterion was weighted subjectively and given a score. The scores for each of the datasets were then summed by means of GIS and then were subjectively generalized into groups. Each group is assumed to represent a certain mineral resource potential.	very high high moderate low very low unknown not classified	not assessed	Pearson and others (1992c)	
Butte 1° x 2° quadrangle, Montana	Descriptive models were developed and recognition criteria were identified for each deposit type. GIS submodels were developed that correspond to these recognition criteria. Within each GIS submodel, a scoring or weighting range was generated that expresses the degree of	very high high moderate low unknown undefined	not assessed	Elliott and others (1993a)	Goudarzi (1984)

	favorability. The final resource assessment maps were derived by combining the submodels into summary GIS models and then assigning levels of mineral potential to the final maps.				
Challis 1° x 2° quadrangle, Idaho	From deposit descriptions, recognition criteria were defined for each deposit type. Maps were prepared for each ore deposit type showing the distribution of mappable criteria. Areas where criteria were present were identified and scored. The scores for each area were summed, giving an indication of relative favorability. Using these scores and any other available geologic knowledge, a resource potential was assigned to each area.	high moderate low no potential	not assessed	Fisher and Johnson (1995)	Taylor and Steven (1983)
Challis National Forest	Assessment methodology was not described but is assumed to be similar to CUSMAP studies.	high moderate unknown	certainty ranked B through D	Worl and others (1989)	Goudarzi (1984)

The modeling approach and use of favorable criteria were first applied by Pratt (1981) to the Rolla quadrangle (Missouri). This approach was adapted and expanded to assessments conducted for the Wallace, Butte, Dillon, and Challis quadrangles (table 1). Levels of potential were defined independently for each study area; the definitions for terms indicating favorability were not systematized until late in the program. The assessments do not explicitly indicate how much undiscovered resource may be present.

Under a Memorandum of Understanding established with the USFS and the United States Bureau of Mines, the USGS conducted assessments of undiscovered mineral resources of selected National Forests beginning in the 1980s and continuing into the 1990s (fig. 2). The first forest assessments employed the methodology used by the CUSMAP studies (for example, the Challis National Forest assessment presented in this report); however, most of the studies were conducted using the 3-part form of assessment currently used by the USGS for undiscovered mineral resource assessments.

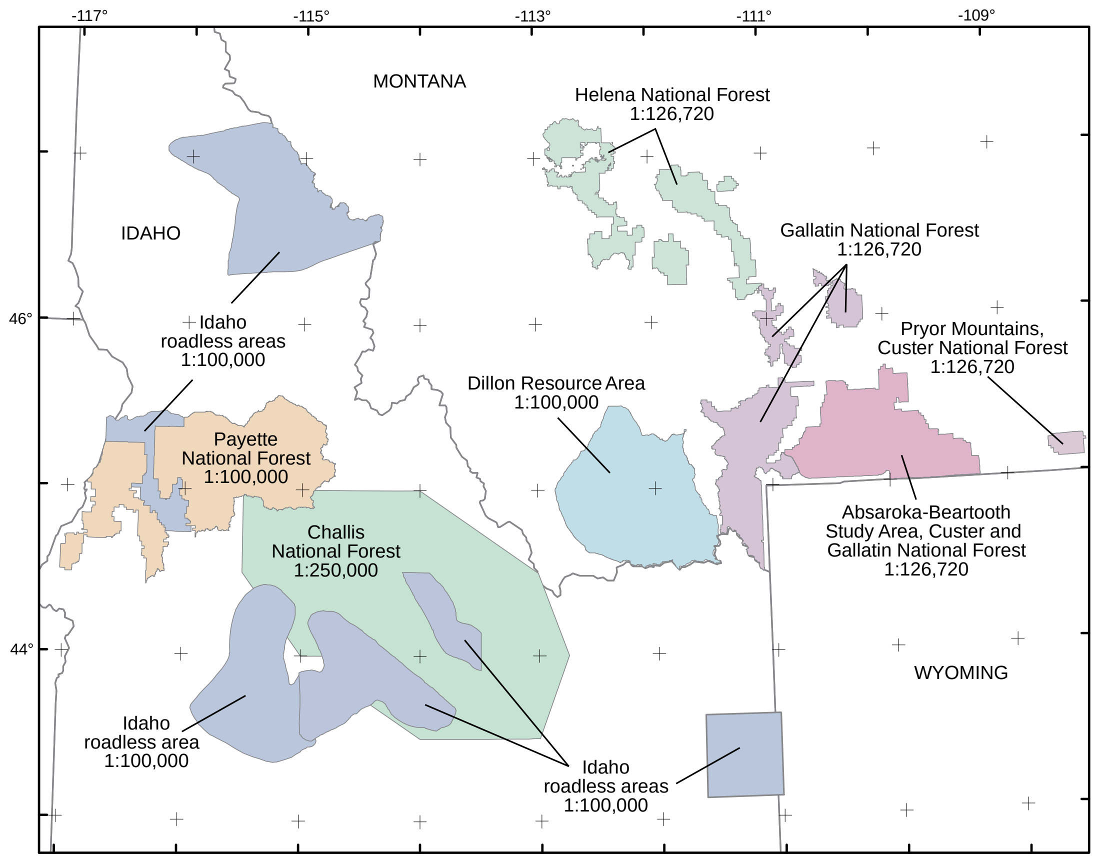

Figure 2. Sketch map of the study area, showing the locations of USFS National Forest and BLM Resource Area assessments conducted by the USGS in Idaho and Montana.

The USGS originally developed the three-part form of assessment to provide quantitative resource information in a form consistent with an economic analysis so that mineral resource values could be compared with values derived from other competing uses of land (Singer, 1993). The assessment results can be evaluated by using economic filters, cash-flow models, and other tools for application to economic, environmental, and policy analysis (Singer, 1993).

The three-part assessment method consists of the following (Singer, 1993):

1. Areas (permissive tracts) are delineated according to the types of deposits permitted by the geology,
2. The amount of metal and some ore characteristics are estimated using grade and tonnage models, and

3. The number of undiscovered deposits of each type is estimated.

Permissive tracts are delineated for one or more deposit types so that the probability of a deposit lying outside the tract is negligible, that is, less than 1 in 100,000 to 1,000,000 (Singer, 1993). The permissive tracts included in this compilation are areas that represent the surface projection of a volume of rock, because the potential for undiscovered deposits is assessed for the uppermost kilometer of the Earth's crust. Designation of a tract as permissive does not imply any special favorability for the occurrence of a deposit, nor does it address the likelihood that a deposit will be discovered there if it exists (Singer, 1993). However, for some studies included in this report, domains within the permissive tracts were identified that showed definitive indications of mineralization consistent with the deposit type being assessed. These domains are called favorable areas within the permissive tracts.

Grade and tonnage models combined with estimates of the number of undiscovered deposits provide resource assessment results in a format that an economist can use. Grade and tonnage models have the form of frequency distributions of tonnages and average grades of well-explored deposits typical of mineral deposit type being modeled (Singer, 1993). Estimates of the number of deposits explicitly represent the probability that a fixed, but unknown, number of undiscovered deposits exist in the delineated tract. Estimates are made by deposit type and must be consistent with the grade and tonnage model. In practice, an expert panel estimates the number of deposits at various percentiles (90^{th}, 50^{th}, 10^{th}, 5^{th}, and so on) using guidelines such as 1) the frequency of known deposits in well explored areas, 2) local deposit extrapolations, 3) process constraints, 4) relative frequencies of related deposits, and 5) area spatial limits (Singer, 1993). The assessment team could also count and assign probabilities to anomalies and occurrences to come up with their estimate. Using Monte Carlo simulation, a probability distribution derived from the estimated number of undiscovered deposits is combined with grade and tonnage models to generate probability distributions of ore and metal tonnages in undiscovered deposits (Root and others, 1992).

In three part assessments, delineated tracts are consistent with descriptive models, grade and tonnage models are consistent with descriptive models, and estimates of the numbers of deposits are consistent with grade and tonnage model. This allows results of quantitative assessments to be compared between similar deposit types in differing study areas. In addition, uncertainty in the assessment is explicitly represented in the probability distributions of ore and metal tonnages.

Data Sources, Processing, and Accuracy

The primary objective of this report is to consistently represent areas of mineral potential shown in the previously published assessment reports as spatial datasets that can be used in a geographic information system (GIS). The data contained in the spatial databases is based on published information: no new interpretations are made. The spatial databases in this report delineate the areas of mineral potential shown on maps in the source assessment reports. For each study area, every deposit type assessed is represented by a separate spatial database. Each spatial database has a consistent set of polygon or arc attributes stored in associated tables. The attribute tables provide information on the deposit type being assessed, the assessment method, the mineral potential rank, and a reference to the assessment report. 183 spatial databases were created for this study (Appendix A).

The first step in preparing this report was to convert all the published assessment results into ArcInfo coverages. The assessment results were available in a variety of formats: paper maps, GSMAP files, ESRI files, and raster images. Results available only as paper maps were digitized, either by the USGS or a vendor, Optronics Specialty Co., Inc. Only some of the digital files have been published; for some study areas, authors of the assessment reports provided us with GIS files they used to create maps and illustrations in their publications. GSMAP files were converted to ArcInfo coverages using conversion software. Raster datasets for the Butte and Dillon CUSMAP studies were vectorized and saved as ArcInfo coverages.

Next, a spatial database was created for each deposit type in a study area. Tracts with potential for multiple deposit types that were combined on a single assessment map were separated. Some areas have potential for more than one deposit type; in this situation, multiple spatial databases were created so that every deposit type had its own separate spatial database.

Study area boundaries were then added to each dataset. The study area boundaries for the National Forests and the 1:100,000 scale maps already existed so they were just combined with the associated datasets. The boundaries for the 1:250,000 scale maps had to be mathematically generated using ArcInfo before combining with the associated datasets.

All datasets utilizing the same assessment methodology were attributed with a common data structure. The attribute table structure for the CUSMAP studies and the Challis National Forest (non-3 part assessments) are identical; similarly, the table structure for all the studies conducted with the 3-part methodology are the same (Absaorka-Beartooth study area, Custer and Gallatin National Forests; Pryor Mountains study area, Custer National Forest; Gallatin National Forest; Helena National Forest; Dillon BLM Resource area; and roadless areas in Idaho national forests).

Finally, each dataset was converted from its original projection to geographic coordinates. The digital files were then plotted and compared to the original maps to check for digitizing and attributing errors. Accuracy was estimated by comparing paper plots to the original mineral potential maps and measuring offset at 10 locations. The overall accuracy (with respect to the location of lines) of the spatial databases ranges between 0 and 6,600 meters depending on the spatial database. Refer to Appendix A for documentation on how each of the original publications was processed and the accuracy of individual datasets.

Digital Documentation

This report has 183 spatial databases representing the results of mineral resource assessments; most databases are line and polygon datasets that represent areas of mineral potential. Only two datasets are line datasets, which represent stream segments with potential for placer gold mineralization.

Line and polygon datasets

These datasets are comprised of polygons delineating areas with potential for a specific deposit type and arcs describing the types of boundaries separating the polygons. The attributes for the polygons are stored in a polygon attribute table, *.PAT. Arcs are described by an arc attribute table, *.AAT. Both the polygon and arc attribute tables refer to ArcInfo lookup tables, *.REF, which contain reference information. Descriptions of the items identifying linear features, such as boundaries (for example, study area boundary, mineral potential boundary) in the arc attribute table, *.AAT, are given in table 2.

Table 2. Summary of user-defined items in ArcInfo arc attribute tables, *.AAT

*.AAT	
ITEM NAME	**ATTRIBUTE DESCRIPTION**
linecode	Integer that identifies type of linear feature.
desc	Description of linear feature. For example, study area boundary, mineral potential boundary.
source	Integer that identifies the data source for the assessment. See ArcInfo lookup table *.REF for complete references.

Descriptions of the polygon attribute table for areas of undiscovered mineral resource potential delineated in the non-3 part assessment studies (CUSMAP studies and the Challis National Forest) are given in table 3.

Table 3. Summary of user-defined items in ArcInfo polygon attribute tables for non 3 part assessments, *.PAT.

*.PAT	
ITEM NAME	**ATTRIBUTE DESCRIPTION**
code	Map symbol used to label the unit on the original resource potential map.
dep_type	The name of the deposit type that was assessed. See original reports for deposit type description.
tract	The name applied to subsets of polygons in the original study.
source	Integer that identifies the data source for the assessment. See ArcInfo lookup table *.REF for complete references.
asses_rank	Term that describes the level of mineral resource potential, for example, low, moderate, high. Refer to original reports for definitions.
cert_rank	Term that describes the certainty level associated with the assessment of mineral potential. For the Challis National Forest, certainty ranks are B, C, and D. Refer to definitions in Goudarzi (1984, p. 8). For the Choteau quadrangle, gpext indicates geophysical extention of tract.
asses_typ	Type of assessment, in this case, non 3-part.

Descriptions of the polygon attribute table, *.PAT for areas of undiscovered mineral resource potential for the 3 part assessment studies are given in table 4.

Table 4. Summary of user-defined items in ArcInfo polygon attribute tables for three part assessments, *.PAT.

*.PAT	
ITEM NAME	**ATTRIBUTE DESCRIPTION**
model_ name	The name of the published USGS deposit model that was assessed. No entry indicates that an informal deposit type was assessed.
model_no	The published USGS deposit model number. No entry indicates an informal deposit type was assessed.
model_source	Integer that identifies the data source for the deposit model. See ArcInfo lookup table *.REF for complete references. No entry indicates an informal deposit type was assessed.
code	Map symbol used to label the unit on the original resource potential map.
dep_type	The name of the informal deposit type that was assessed. See original reports for deposit type description. No entry indicates a published USGS deposit model was assessed.
tract	The name applied to subsets of polygons in the original study.
source	Integer that identifies the data source for the assessment. See ArcInfo lookup table *.REF for complete references.
asses_rank	Term that describes the level of mineral resource potential, for example, permissive or favorable. See text and Singer (1993) for definitions.
asses_typ	Type of assessment, in this case, 3-part.

Line only datasets

Two assessment datasets, ABPLACAUG and HNFAUPLAG, are comprised only of arcs delineating potential for placer gold. They are described by an arc attribute table, *.AAT, that refers to ArcInfo lookup tables, *.REF. Descriptions the arc attribute table for these datasets are given in table 5.

Table 5. Summary of user-defined items in ArcInfo arc attribute tables ABPLACAUG.AAT and HNFAUPLAG.AAT.

ABPLACAUG.AAT and HNFAUPLAG.AAT	
ITEM NAME	**ATTRIBUTE DESCRIPTION**
linecode	Integer that identifies type of linear feature.
desc	Description or explanation of linear feature. For example, study area boundary, stream segment.
dep_type	The name of the informal deposit type that was assessed, in this case, placer gold. See original reports for deposit type description.
tract	The name applied to subsets of arcs in the original study.
source	Integer that identifies the data source for the linear feature. See ArcInfo lookup tables ABPLACAU.REF and HNFPLAAU.REF for complete references..
asses_rank	Term that describes the level of mineral resource potential, for example, permissive. See text and Singer (1993) for definitions.
asses_typ	Type of assessment, in this case, 3-part.

Source Attributes

Descriptive source or reference information for the spatial datasets is stored in the ArcInfo lookup tables *.REF. Attribute descriptions for items in the *.REF data source files are given in table 6.

Table 6. Summary of ArcInfo lookup tables, *.REF.

*.REF	
ITEM NAME	ATTRIBUTE DESCRIPTION
source	Integer that identifies the data source.
scale	Source scale of the mineral resource map.
authors	Author(s) or compiler(s) of source map entered as last name, first name or initial, and middle initial.
year	Source (map) publication date
reference	Remainder of reference in USGS reference format.

Summary

In the years following the USGS mineral resource assessments, GIS has become an essential part of the land-use planning process, allowing spatial information from many disciplines to be compared and integrated. Although the results of these mineral assessment studies were available in published reports and maps, their impact in the land-use planning process was lessened because the data was not available in a digital format amenable to spatial analysis. This report begins the process of providing these mineral assessment results in a format that can be used in GIS-based land-use planning efforts.

This report displays the areas of mineral potential and provides attribute information about the type of mineralization that may be present, the level of potential, and a reference. As an example of the type of results that can be derived from these datasets, figures 3 and 4 illustrate the mineral potential associated with porphyry copper-type mineralization, figures 5 and 6 illustrate the assessments results for sediment-hosted copper-type mineralization, and figures 7 and 8 show results for sedimentary exhalative lead-zinc-type mineralization. However, these datasets are limited because they do not convey the depth of information that is available in the original reports. Users of these datasets should refer to the published assessment results, particularly those in which quantitative estimates of the amounts of undiscovered resources were made.

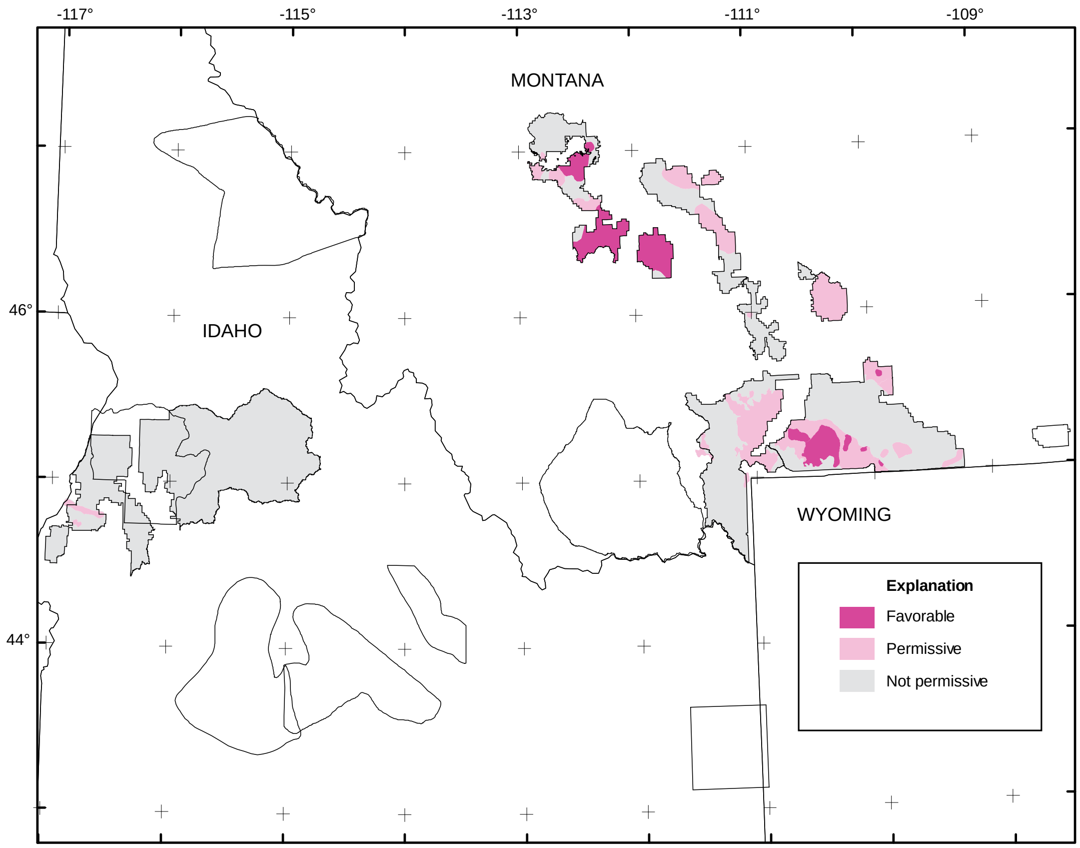

Figure 3. Sketch map of the study area, showing areas identified in USGS assessments of USFS National Forests in Idaho and Montana that are permissive and favorable for undiscovered porphyry Cu-style mineralization.

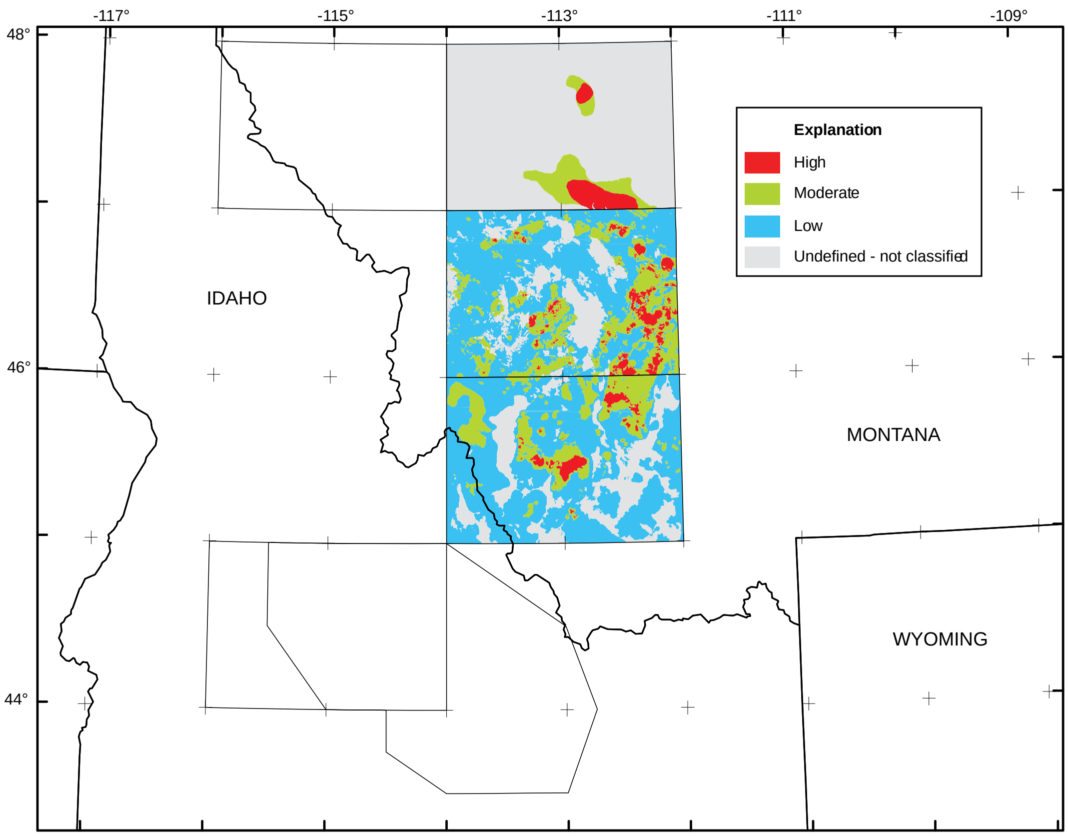

Figure 4. Sketch map of the study area, showing areas identified in USGS 1° x 2° quadrangle assessments in Idaho and Montana that have potential for undiscovered porphyry copper-style mineralization.

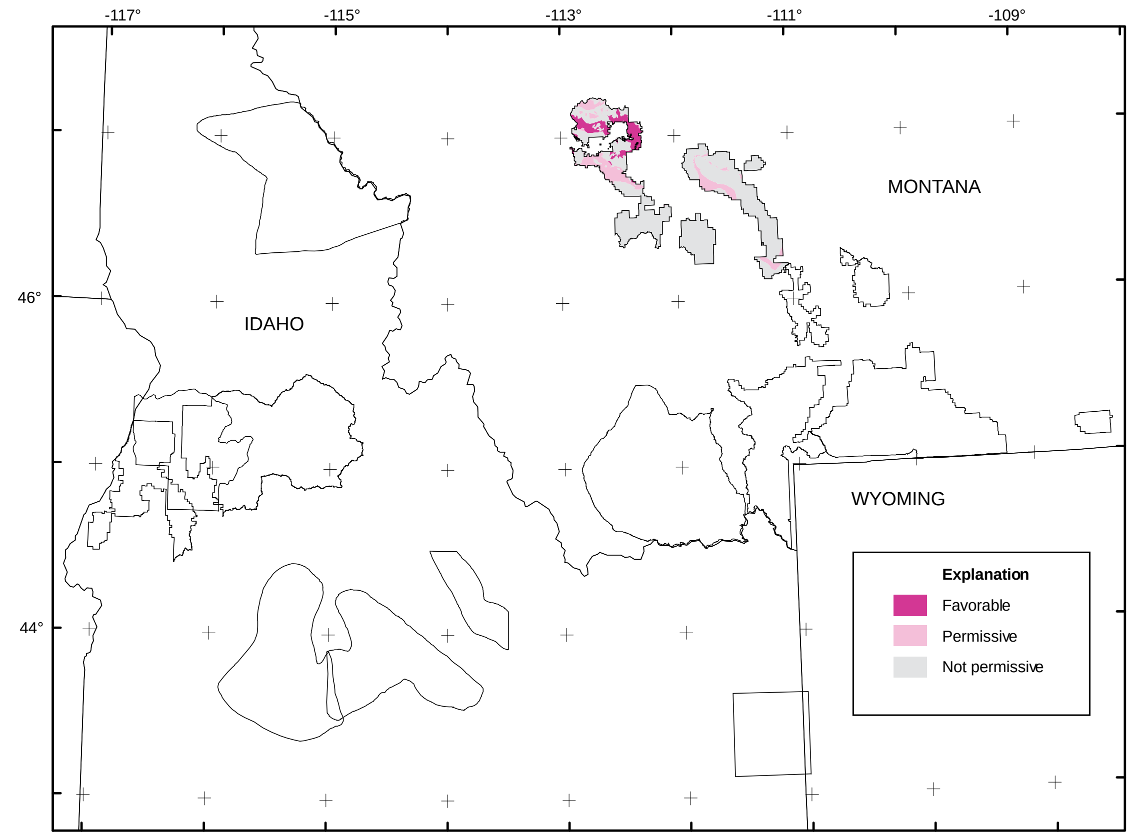

Figure 5. Sketch map of the study area, showing areas identified in USGS assessments of USFS National Forests in Idaho and Montana that are permissive and favorable for undiscovered sediment-hosted copper-style mineralization.

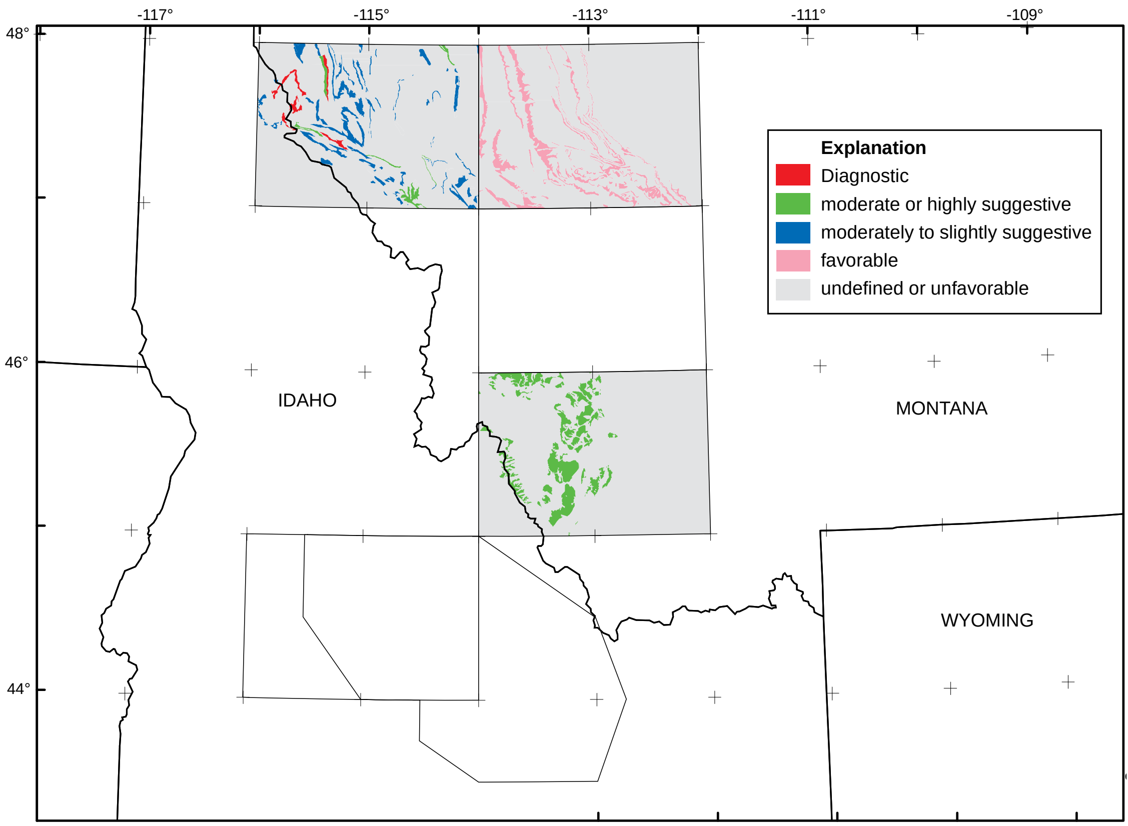

Figure 6. Sketch map of the study area, showing areas identified in USGS 1° x 2° quadrangle assessments in Idaho and Montana that have potential for undiscovered sediment-hosted copper-style mineralization.

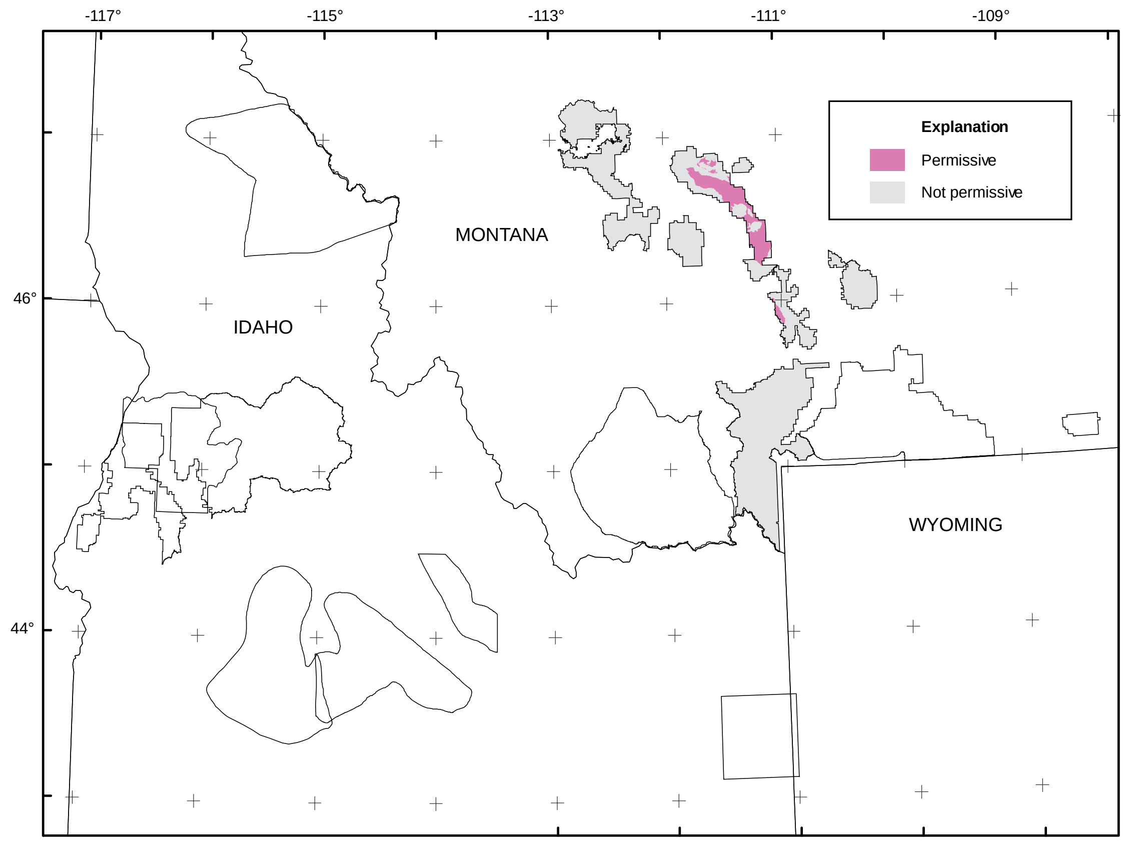

Figure 7. Sketch map of the study area, showing areas identified in USGS assessments of USFS National Forests in Idaho and Montana that are permissive and favorable for undiscovered sedimentary exhalative lead-zinc-style mineralization.

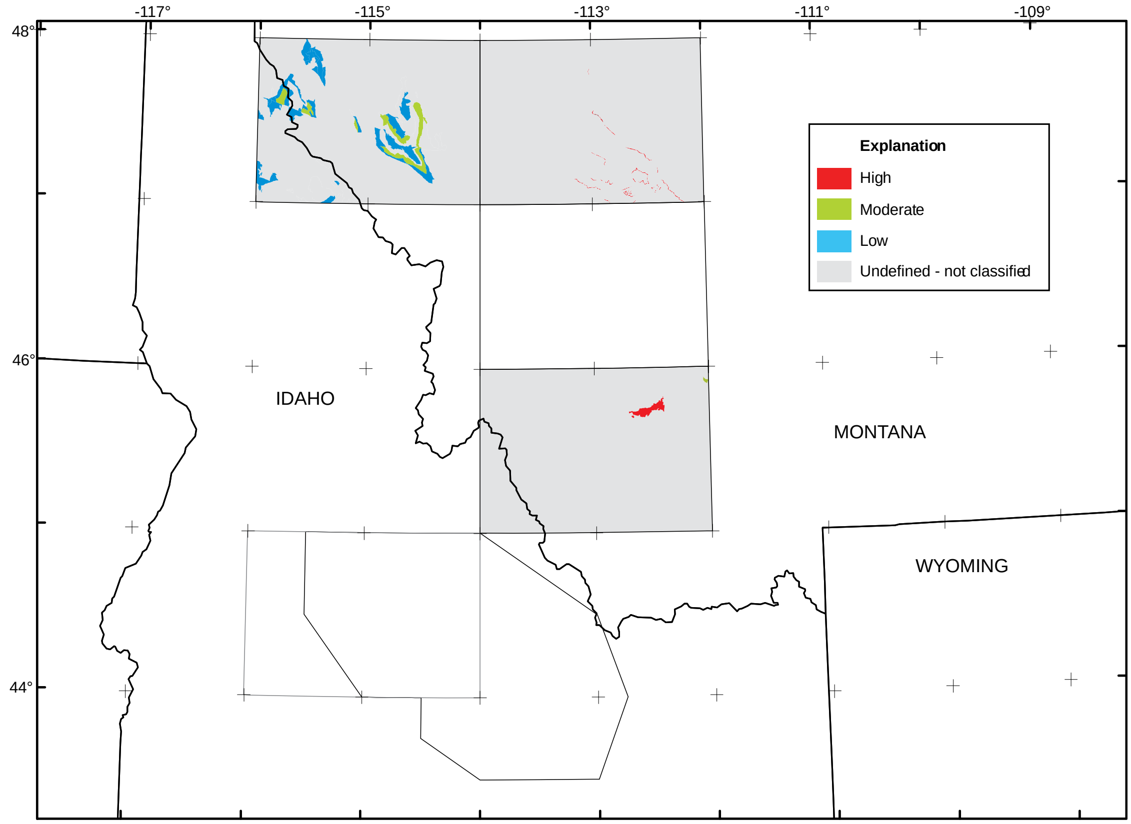

Figure 8. Sketch map of the study area, showing areas identified in USGS 1° x 2° quadrangle assessments in Idaho and Montana that have potential for undiscovered sedimentary exhalative lead-zinc-style mineralization.

Inconsistencies in the name of mineral deposit types and models may confuse some users, although the terminology will be familiar to geologists with a background in economic geology. All users will benefit by referring to published descriptions of mineral deposit models, both those included in the original reports as well as separate compilations (such as Cox and Singer, 1986). Stoesser and Heran (2000) assembled many mineral deposit models published by the USGS into a single report.

The USGS subsequently published regional assessments that include Idaho and Montana, including a national mineral resource assessment (U.S. Geological Survey National Mineral Resource Assessment Team, 2000) and an assessment conducted for the Interior Columbia Basin Ecosystem Management Project (Box and others, 1996). Spatial databases are available for both of these datasets; however, these studies considered a limited number of commodities and had to generalize information due to the scale of the assessment (approximately 1:1,000,000). These regional assessments provide an important overview; however, the scale of the assessments included in this report are better suited to regional planning, consider more deposit types, and provide more in-depth analysis. Boleneus and others (2005) published an assessment of sediment-hosted copper mineralization in the Revett Formation in northern Idaho and northwestern Montana; spatial datasets are available in that report.

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Appendix A. List of ArcInfo datasets representing areas of mineral potential from CUSMAP and National Forest mineral resource assessments in Idaho and Montana.

ArcInfo interchange-format file name	Deposit type assessed	Source material	The overall horizontal accuracy (+/-) of the spatial digital databases, in meters	Reference
Three-part form mineral resource assessments				
Absaroka-Beartooth study area, Custer and Gallatin National Forests, Montana, scale 1:126,720				
aba_dvnsg.e00	polymetallic veins	Unpublished GSMAP files were converted to ArcInfo datasets.	380	Hammarstrom and others (1993)
abalkpgeg.e00	alkaline gabbro-syenite-hosted copper-gold-PGE deposits	do	444	do
abalsufeg.e00	Algoma/Superior iron	do	317	do
abauagtg.e00	gold-silver-tellurium veins	do	272	do
abausknsg.e00	gold-bearing skarn	do	253	do
abbcevnsg.e00	polymetallic veins	do	272	do
abbuscrg.e00	Bushveld chromite deposits	do	190	do
abdispgeg.e00	discordant PGE	do	190	do
abepivng.e00	epithermal vein	do	253	do
ablodeaug.e00	Homestake Au	do	222	do
abmrpgeg.e00	Merensky Reef platinum-group elements (PGE)	do	127	do
abpegmatg.e00	pegmatite deposits	do	222	do
abplacaug.e00	placer gold deposits	do	158	do
abporcug.e00	porphyry copper	do	253	do
abppppgeg.e00	Picket Pin PGE	do	127	do
abredcrg.e00	Red Lodge chromite	do	190	do
abserpasg.e00	serpentine-hosted asbestos	do	190	do
abstnicug.e00	Stillwater nickel-copper	do	127	do
abstracrg.e00	PGE-enriched stratiform chromitite	do	127	do
aburang.e00	uranium deposits	do	190	do

ArcInfo interchange-format file name	Deposit type assessed	Source material	The overall horizontal accuracy (+/-) of the spatial digital databases, in meters	Reference
Dillon BLM Resource Area, scale 1:250,000				
drabdrgtg.e00	bedrock garnet	Unpublished ArcInfo datasets.	950	Van Gosen and others (1998b)
dragarplg.e00	garnet placer	do	1014	do
dratalcg.e00	talc deposits	do	1267	Van Gosen and others (1998a)
draulmafg.e00	mafic or ultramafic rock	do	800	Hammarstrom and others (1999)
Gallatin National Forest (exclusive of the Absaroka-Beartooth study area), scale 1:126,720				
galalksyg.e00	alkaline gabbro-syenite hosted copper-gold-PGE deposits	Unpublished ArcInfo datasets.	507	Wilson and others (2005)
galauagtg.e00	gold-silver-telluride vein	do	760	do
galauskng.e00	gold-bearing skarn	do	2028	do
galchromg.e00	mafic/ultramafic-hosted chromite	do	1690	do
galcorung.e00g	corundum–sillimanite deposits	do	1690	do
galepivng.e00	epithermal vein deposits	do	2028	do
galnicug.e00	magmatic Ni, Cu, PGE deposits	do	1690	do
galpegmag.e00	pegmatite deposits	do	1690	do
galphospg.e00	upwelling-type phosphate deposits	do	2028	do
galpmvbmg.e00	polymetallic replacement	do	2028	do
galpmvg.e00	polymetallic veins	do	2534	do
galporcug.e00	porphyry copper	do	2028	do
galserpag.e00	serpentine-hosted asbestos	do	1690	do
galtaleqg.e00	talc associated with dolomitic rocks	do	1690	do
galtalshg.e00	talc associated with ultramafic rocks	do	1690	do
galvermg.e00	vermiculite deposits	do	2028	do
galxznpbg.e00	sedimentary exhalative zinc-lead deposits	do	760	do
Helena National Forest, scale 1:126,720				
hnfauplag.e00	placer gold	Published ArcInfo datasets.	750	Tysdal and others (1996); Green and

ArcInfo interchange-format file name	Deposit type assessed	Source material	The overall horizontal accuracy (+/-) of the spatial digital databases, in meters	Reference
				Tysdal (1996)
hnfauskng.e00	gold skarn	do	62.5	do
hnfauvnsg.e00	Cretaceous gold-bearing vein	do	250	do
hnfclimog.e00	Climax molybdenum	do	438	do
hnfexhaug.e00	York-type exhalative (?) gold deposits	do	125	do
hnfeznpbg.e00	sedimentary exhalative zinc-lead deposits	do	275	do
hnfgoldg.e00	gold deposits	do	375	do
hnfhagaug.e00	hot-spring gold-silver	do	438	do
hnflimdog.e00	limestone and dolomite	Polygons with the label attribute = 'Kk, Kju, Ju, PPMu, PPq, Pma, Ysh, Yh, Yn, Mm, MDCu, Mdu, Cu, Crh, Cmu, Cmw' in the geology coverage (Tysdal and others, 1996; Green and Tysdal, 1996) were selected to represent the *hnflimdog* dataset.	438	do
hnfpmrplg.e00	polymetallic replacement	Published ArcInfo datasets.	438	do
hnfpolvng.e00	polymetallic vein	do	375	do
hnfporcug.e00	porphyry copper	do	313	do
hnfquadug.e00	epithermal vein, quartz adularia	do	250	do
hnfredcug.e00	sediment-hosted copper, redbed type	do	250	do
hnfwskrng.e00	tungsten- (molybdenum) skarn	do	125	do
National Forest Roadless Areas in Idaho, scale 1:100,000				
id1clfmog.e00	Cretaceous low-fluorine porphyry molybdenum deposits	Unpublished GSMAP files were converted to ArcInfo datasets.	697	Johnson and Worl (1991)
id1ctevg.e00	Comstock epithermal vein	do	634	do
id1pqvnlg.e00	polymetallic quartz vein and lode (mixed base- and precious metal veins)	do	1267	do
id1rbsdpg.e00	radioactive black sand placers	do	634	do
id1tlfmog.e00	Tertiary low-fluorine porphyry molybdenum deposits	do	697	do
id2clfmog.e00	Cretaceous low-fluorine porphyry molybdenum	do	845	do

ArcInfo interchange-format file name	Deposit type assessed	Source material	The overall horizontal accuracy (+/-) of the spatial digital databases, in meters	Reference
id2ctevng.e00	Comstock epithermal veins	do	1478	do
id2polvng.e00	polymetallic veins	do	634	do
id2pqvnlg.e00	polymetallic quartz vein and lode (mixed base- and precious metal veins)	do	1267	do
id2tpomog.e00	Tertiary low-fluorine porphyry molybdenum	do	1690	do
id2znpbsg.e00	Zn-Pb skarn deposits	do	849	do
id3bcocug.e00	sediment-hosted (Blackbird-type) cobalt-copper deposits	do	1267	do
id3losaug.e00	low-sulfide gold deposits	do	475	do
id3plaaug.e00	placer gold	do	634	do
id3pqvnlg.e00	polymetallic quartz vein and lode (mixed base- and precious metal veins)	do	697	do
id3rbsdpg.e00	radioactive black sand placers	do	1109	do
id3stvolg.e00	stratabound volcanogenic deposits (Kuroko massive sulfide)	do	634	do
id3wskarg.e00	tungsten skarn	do	950	do
id4ctevng.e00	Comstock epithermal veins	do	1564	do
id4metkyg.e00	metamorphic kyanite	do	1173	do
id4plaaug.e00	placer gold	do	978	do
id4polvng.e00	polymetallic veins	do	1564	do
id4pqvnlg.e00	polymetallic quartz vein and lode (mixed base- and precious metal veins)	do	1173	do
id5kphlag.e00	upwelling-type phosphate deposits	do	158	do
Payette National Forest, scale 1:100,000				
pnfauagvg.e00	gold-silver mixed-metal veins (mixed base- and precious-metal veins)	Published ArcInfo datasets.	81	Bookstrom and others (1998)
pnfauskng.e00	Au-bearing skarn	do	122	do
pnfbaritg.e00	barite layers and veins	do	1584	do

ArcInfo interchange-format file name	Deposit type assessed	Source material	The overall horizontal accuracy (+/-) of the spatial digital databases, in meters	Reference
pnfcuagpg.e00	copper-silver polymetallic vein	do	1267	do
pnfdcuagg.e00	disseminated copper-silver	do	5069	do
pnfddgsg.e00	distal disseminated gold-silver	do	122	do
pnfdissbg.e00	disseminated antimony (simple Sb) deposits	do	122	do
pnfgypsug.e00	gypsum and anhydrite	do	4118	do
pnfhsaug.e00	hot spring gold-silver	do	609	do
pnfhshgg.e00	hot spring mercury deposits	do	0	do
pnfkurokg.e00	Kuroko zinc-copper massive sulfide (Kuroko massive sulfide)	do	1584	do
pnflosaug.e00	low sulfide Au-quartz veins	do	1901	do
pnfmmvcug.e00	copper-gold mixed-metal veins	do	41	do
pnfmnlvg.e00	manganese layer and veins (Franciscan-type volcanogenic manganese)	do	5702	do
pnfplyvng.e00	polymetallic layers and veins	do	3802	do
pnfporcug.e00	porphyry copper-molybdenum	do	3168	do
pnfsbvnsg.e00	antimony veins (simple Sb deposits)	do	122	do
pnfskncug.e00	Cu skarn	do	4118	do
pnfsknfeg.e00	iron skarn	do	4118	do
pnfwskarg.e00	W skarn	do	406	do
pnfwveing.e00	tungsten veins – quartz-huebnerite (W veins)	do	122	do
pnfznpbsg.e00	Zn-Pb skarn	do	41	do
Pryor Mountains, Custer National Forest; scale 1:126,720				
pryhplimg.e00	high-purity limestone	Unpublished ArcInfo datasets.	127	Van Gosen and others (1996)
pryurvang.e00	uranium-vanadium (solution-collapse breccia pipe uranium deposits)	do	127	do
Non 3-part form mineral resource assessments				
Butte 1° x 2° quadrangle, scale 1:250,000				
buporphg.e00	porphyry/stockwork deposits of	Unpublished raster data files used in	500	Elliott and others

ArcInfo interchange-format file name	Deposit type assessed	Source material	The overall horizontal accuracy (+/-) of the spatial digital databases, in meters	Reference
	copper, molybdenum, and tungsten	conducting the CUSMAP assessment were vectorized to create ArcInfo datasets.		(1993b)
buskarng.e00	skarn gold, silver, copper, tungsten, and iron	do	500	Elliott and others (1992a)
bustockg.e00	stockwork/disseminated deposits of gold and silver	do	625	Elliott and others (1993b)
buveing.e00	vein deposits of gold, silver, copper, lead, zinc, tungsten, and manganese	do	500	Elliott and others (1992b)
Challis 1° x 2° quadrangle, scale 1:250,000				
ch250argg.e00	stratabound syngenetic dep. of precious and base metals in argillite and micritic limestone	Selected arcs and polygons were digitized from paper maps to create ArcInfo datasets.	438	Fisher and Johnson (1995)
ch250aupg.e00	gold placer	do	500	do
ch250bcfg.e00	stratabound, stratiform, breccia-controlled fluorspar deposits in carbonate rocks	do	250	do
ch250bpmg.e00	mixed base- and precious-metal vein	do	188	do
ch250bspg.e00	radioactive black sand placer	do	875	do
ch250cmog.e00	Cretaceous molybdenum stockworks	do	250	do
ch250cog.e00	stratabound syngenetic cobalt copper	do	250	do
ch250epig.e00	precious-metal deposits in epiclastic sediments	do	250	do
ch250fvng.e00	fluorspar vein	do	500	do
ch250hgrg.e00	mercury replacement	do	250	do
ch250pbvg.e00	lead-silver-zinc-antimony-tin vein	do	250	do
ch250pmvg.e00	precious-metal vein	do	500	do
ch250pskg.e00	polymetallic skarn	do	375	do
ch250rhyg.e00	precious-metal deposits hosted by high level rhyolites	do	250	do
ch250rplg.e00	replacement deposits of base and	do	250	do

ArcInfo interchange-format file name	Deposit type assessed	Source material	The overall horizontal accuracy (+/-) of the spatial digital databases, in meters	Reference
	precious metals			
ch250stug.e00	stratiform uranium in sedimentary rocks	do	500	do
ch250stvg.e00	stratabound vanadium	do	500	do
ch250tmog.e00	Tertiary molybdenum stockworks	do	313	do
ch250tufg.e00	precious metal deposits in volcanic tuffs	do	62.5	do
ch250uvng.e00	uranium vein	do	250	do
ch250wvrg.e00	tungsten vein and replacement	do	250	do
Challis National Forest, scale 1:250,000				
chnfauplg.e00	gold placers	The original published maps were scanned and vectorized by Optronics Specialty Co., Inc. to create ArcInfo datasets.	1000	Worl and others (1989)
chnfbkshg.e00	polymetallic veins in black-shale terrane	do	1000	do
chnfbmvng.e00	base metal veins	do	1000	do
chnfbrecg.e00	fluorspar breccia manto deposits	do	875	do
chnfcarbg.e00	polymetallic veins in carbonate terrane	do	625	do
chnfflvng.e00	fluorspar veins	do	750	do
chnfibpmg.e00	irregular replacements of base and precious metals	do	500	do
chnfjaspg.e00	sediment-hosted, jasperoid-associated, precious-metal deposits	do	500	do
chnfpmvng.e00	precious-metal veins	do	813	do
chnfpskng.e00	polymetallic skarn deposits	do	1250	do
chnfquarg.e00	polymetallic veins in quartzite terrane	do	625	do
chnfrbspg.e00	radioactive black sand placer	do	750	do
chnfrhyog.e00	high-level, rhyolite-hosted, precious-metal deposits	do	625	do
chnfstmog.e00	stockwork molybdenum deposits	do	625	do
chnfstrvg.e00	stratiform vanadium deposits	do	500	do

ArcInfo interchange-format file name	Deposit type assessed	Source material	The overall horizontal accuracy (+/-) of the spatial digital databases, in meters	Reference
chnfstsyg.e00	stratabound syngenetic deposits of precious and base metals	do	500	do
chnftextg.e00	polymetallic veins in Tertiary extrusive terrane	do	750	do
chnftuffg.e00	precious-metal deposits in volcanic tuffs	do	500	do
chnfunkng.e00	The presence of mineralization is suggested but definitive data is not available to indicate the type or kind.	do	750	do
chnfurang.e00	vein uranium deposits	do	625	do
chnfwsvng.e00	tungsten stockwork and vein deposits	do	938	do
Choteau 1° x 2° quadrangle, scale 1:250,000				
chotaulog.e00	gold lode deposits	The original published maps were scanned and vectorized by Optronics Specialty Co., Inc. to create ArcInfo datasets.	250	Earhart and others (1981b)
chotaupg.e00	gold placer deposits	do	500	do
chotbarvg.e00	vein deposits of barite	do	750	do
chotcumog.e00	porphyry copper-molybdenum deposits	do	438	do
chotgrbdg.e00	greenbed copper-silver deposits	do	750	do
chotheleg.e00	stratabound lead-zinc and copper-silver deposits in calcareous quartzite of the Helena Formation	do	750	do
chotmagg.e00	titaniferous magnetite deposits	do	563	do
chotpbzng.e00	fracture filling and replacement lead-zinc deposits	do	438	do
chotpsilg.e00	copper-lead-zinc mineralized veins associated with Proterozoic Z sills	do	750	do
chotquarg.e00	stratabound copper-silver deposits in gray quartzite	do	1000	do
chottintg.e00	polymetallic vein deposits associated with Tertiary	do	250	do

ArcInfo interchange-format file name	Deposit type assessed	Source material	The overall horizontal accuracy (+/-) of the spatial digital databases, in meters	Reference
	intrusives			
Dillon 1° x 2° quadrangle, scale 1:250,000				
dichlorig.e00	chlorite deposits	The original published maps were scanned and vectorized by Optronics Specialty Co., Inc. to create ArcInfo datasets.	750	Pearson and others (1990)
dichromig.e00	chromite deposits	do	750	do
digraphig.e00	graphite deposits	do	625	do
diironfmg.e00	bedded iron-formation	do	750	do
dinickelg.e00	nickel deposits	do	750	do
diporphg.e00	porphyry copper and molybdenum	Unpublished raster data files used in conducting the CUSMAP assessment were vectorized to create ArcInfo datasets.	250	Pearson, Trautwein and others (1992b)
diqplacrg.e00	placer gold and silver in modern stream valleys	do	500	Pearson and others (1991)
diskarng.e00	skarn deposits	do	438	Pearson, Trautwein and others (1992b)
distcuagg.e00	Belt-type stratabound copper-silver deposits	The original published maps were scanned and vectorized by Optronics Specialty Co., Inc. to create ArcInfo datasets.	750	Pearson and others (1990)
disupbzng.e00	Sullivan-type stratabound lead-zinc-silver	do	500	do
ditalcg.e00	talc deposits	do	688	do
ditplacrg.e00	placer gold and silver in Tertiary sediments	Unpublished raster data files used in conducting the CUSMAP assessment were vectorized to create ArcInfo datasets.	500	Pearson and others (1991)
diveing.e00	vein and replacement deposits of base and precious metals, barite and fluorspar	do	375	Pearson, Trautwein, and others (1992a)
dixaubasg.e00	exhalative deposits of gold and base metals	The original published maps were scanned and vectorized by Optronics Specialty Co., Inc. to create ArcInfo datasets.	813	Pearson and others (1990)
diyecocug.e00	Blackbird-type cobalt-copper-gold	do	750	do
Wallace 1° x 2° quadrangle, scale 1:250,000				
wa250aupg.e00	placer gold	Lines were selected from the Wallace	313	Harrison,

ArcInfo interchange-format file name	Deposit type assessed	Source material	The overall horizontal accuracy (+/-) of the spatial digital databases, in meters	Reference
		1:250,000 digital geologic map (Harrison, Griggs, and others, 2000) that match the lines representing potential for placer Au and pasted into a new dataset. Additional lines were digitized from Harrison, Cressman and others (1986).		Domenico, and Leach (1986a)
wa250esdg.e00	epithermal silver	Selected arcs and polygons were digitized from paper maps to create ArcInfo datasets.	313	Harrison and others (1986b)
wa250mvg.e00	mesothermal veins	do	250	Harrison and others (1986a)
wa250pgmg.e00	platinum group metal	do	188	Harrison and others (1986b)
wa250pmtg.e00	porphyry molybdenum-tungsten	do	438	do
wa250scsg.e00	stratabound copper-silver deposits	Lines were selected from the Wallace 1:250,000 digital geologic map (Harrison, Griggs, and others, 2000) that match the lines representing potential for stratabound Cu-Ag and pasted into a new dataset. Additional lines were digitized from Harrison, Domenico and Leach (1986).	500	Harrison, Domenico, and Leach (1986b)
wa250sslg.e00	Sullivan type stratabound lead-zinc-silver	Selected arcs and polygons were digitized from paper maps to create ArcInfo datasets.	375	Harrison, Cressman, and others (1986)